CAREERS IN PHYSICS

An Amusing Side of Physics

Your roller-coaster car is heading up the first and highest incline. As you turn around to wave to your faint-of-heart friends on the ground, you realize that six large players from the Hamilton Tiger Cats football team have piled into the three cars immediately behind you! Now you're poised at the top, ready to drop, and hoping fervently that the roller-coaster manufacturer designed the cars to stay on the track, even when carrying exceptionally heavy loads.

Perhaps your anxiety will lessen if you are aware that a highly qualified mechanical engineer, such as Matthew Chan, has checked out the performance specifications of the roller coaster, as well as all of the other rides at the amusement park. They meet Canada's safety codes, or the park is not allowed to operate them.

Chan has worked for the Technical Standards and Safety Authority (TSSA) for the past 11 years. As special devices engineer for the Elevating and Amusement Devices Safety Division, he spends most of his time in the office, verifying design submissions from elevator, ski lift, and amusement park ride manufacturers.

When some unique piece of machinery comes along or when he wants to verify how equipment will perform in reality versus on paper, Chan goes into the field. He confesses a special fondness for going on-site to test amusement park rides, including at Canada's Wonderland, north of Toronto, the Western Fair in London, Ontario, and Toronto's Canadian National Exhibition.

His favourite challenge is analyzing the performance of reverse bungees, amusement park rides that look like giant slingshots and that hurl people hundreds of feet into the air. Chan says that most reverse bungees are unique devices — rarely are two designed and made exactly the same. "It takes all of your engineering knowledge to analyze these devices," claims Chan. "There are no hard and fast rules for how reverse bungees are made, and the industry is always changing."

A reverse bungee ride

A university degree in mechanical engineering is required to become a special devices engineer, and Chan says that an understanding of the dynamics of motion is a must. You have to be able to predict how a device will behave in a variety of "what if" scenarios. The details of balance, mass placement, overload situations, restraint systems, and footings are all worked through carefully.

In short, you are in good hands. Now, sit back, relax, and enjoy the ride!

Going Further

1. According to Chan, one of the best ways to get a hands-on feel for the complex dynamic forces at work in amusement park rides is to build and operate scale models. Form a study group with some of your friends and investigate designs for your favourite ride. Build a scale model and test it to determine the smallest and greatest weights it can carry safely.

2. Visit a science centre that has exhibits demonstrating the principles of dynamics.

WEB LINK

www.mcgrawhill.ca/links/physics12

The Internet has sites that allow you to design and "run" your own amusement park rides. Go to the Internet site shown above and click on **Web Links**.

PROBEWARE

If your school has probeware equipment, visit ***www.mcgrawhill.ca/links/physics12*** and follow the links for an in-depth activity on circular motion.

Describing Rotational Motion

When an object is constantly rotating, physicists sometimes find it more convenient to describe the motion in terms of the frequency — the number of complete rotations per unit time — or the period — the time required for one complete rotation — instead of the velocity of the object. You can express the centripetal acceleration and the centripetal force in these terms by finding the relationship between the magnitude of the velocity of an object in uniform circular motion and its frequency and period.

- Write the definition of velocity. Since period and frequency are scalar quantities, omit vector notations.

$$v = \frac{\Delta d}{\Delta t}$$

- The distance that an object travels in one rotation is the circumference of the circle.

$$\Delta d = 2\pi r$$

- The time interval for one cycle is the period, T.

$$\Delta t = T$$

- Substitute the distance and period into the equation for velocity, v.

$$v = \frac{2\pi r}{T}$$

- Substitute the above value for v into the equation for centripetal acceleration, a, and simplify.

$$a_c = \frac{v^2}{r}$$

$$a_c = \frac{\left(\frac{2\pi r}{T}\right)^2}{r}$$

$$a_c = \frac{\frac{4\pi^2 r^{\cancel{2}}}{T^2}}{\cancel{r}}$$

$$a_c = \frac{4\pi^2 r}{T^2}$$

- Substitute the above value for a into the equation for centripetal force and simplify.

$$F_c = ma_c$$

$$F_c = m\left(\frac{4\pi^2 r}{T^2}\right)$$

$$F_c = \frac{4\pi^2 mr}{T^2}$$

- The frequency is the inverse of the period.

$$f = \frac{1}{T} \text{ or } T = \frac{1}{f}$$

- Substitute the above value for the period into the equation for centripetal acceleration and simplify.

$$a_c = \frac{4\pi^2 r}{\left(\frac{1}{f}\right)^2}$$

$$a_c = 4\pi^2 rf^2$$

- Substitute the above value for acceleration into the equation for the centripetal force.

$$F_c = m(4\pi^2 rf^2)$$

$$F_c = 4\pi^2 mrf^2$$